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OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAMME OF THE

EVANSTON MEETING

AT

NORTHWESTERN UNIVERSITY

EVANSTON, ILLINOIS

November 12 and 13, 1943

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The American Physical Society

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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

EVANSTON MEETING, NOVEMBER 12–13, 1943

THE **257th meeting of the American Physical Society** will be held in the Technological Institute of Northwestern University at Evanston, Illinois, on Friday and Saturday, November 12 and 13, 1943. For the benefit of those few who may not be acquainted with the Chicago area, it is here stated that Evanston adjoins Chicago on the north. The traditional "Thanksgiving meeting at Chicago" thus becomes a meeting which is neither at Thanksgiving nor strictly in Chicago; it is expected that these changes will prove to be examples of novelties which though suggested by wartime conditions are not detrimental. Another welcome novelty is the notable symposium "Physics of Rubber and other High Polymers," of a type which may be without precedent in our history but will surely be represented by many future examples. For the organization of this symposium the principal credit belongs to Warren F. Busse.

Hotels. The Edgewater Beach Hotel, on the lake front of Chicago in the 5300 block of Sheridan Road, is pleasantly and conveniently located between the center of Chicago and the place of our meetings. It offers rooms at $4.40 single, $6.60 double, and $11 for each of a few suites accommodating four people. Hotels in Evanston include the Orrington, 1710 Orrington Avenue, (single $3 and up, double $4 and up); the North Shore, 1611 Chicago Avenue (double at $6); the Evanston, 840 Forest Avenue (single $2.75, double $4.50); and the Y.M.C.A. at 1000 Grove Street. (Those who have traveled lately will know that early reservation is highly advisable; others are warned to this effect.)

The **way to Evanston from Chicago** is by the elevated railway from the Loop stations at Adams and Wabash or State and Randolph; the trains are marked "Evanston Shoppers Special"; the place to get off is Noyes Street, Evanston, from which walk east three blocks. The Edgewater Beach Hotel is close to the intermediate station called Edgewater Beach, but one must take a train marked "Howard Street Express." Time to be allowed: one hour from the Loop, thirty minutes (with change at Howard Street) from the Edgewater Beach. Taxi fare from the Loop to the Edgewater Beach Hotel is about $1.40.

The **registration-desk** (where all members and guests are asked to register) will be located in the Technological Institute near the main entrance.

The **symposium on the physics of rubber and other high polymers** will commence on Friday morning at ten, continue throughout the afternoon and terminate on Saturday morning. It will probably be held in Room 6, but visitors should watch for posters indicating changes in room assignments.

Sessions for **contributed ten-minute papers** will occur on Friday afternoon and on Saturday morning and afternoon, probably in Room 7 or 8. Visitors should watch for posters indicating changes in room assignments.

The **dinner** of the Society, at which all who are interested in the meetings will be welcome, will be held at the Georgian Hotel in Evanston

at seven o'clock on Friday evening at a price of $1.75 per plate. Members and guests are asked to make advance reservation by letter or card addressed to Professor B. J. Spence at Northwestern University, Evanston, Illinois. To make this easier a form of reservation has been printed on the inside back cover page of this Bulletin. Tickets will be held at our Registration Desk. No promise of accommodation can be made to anyone who does not ask before Friday noon.

The **Council of the American Physical Society** will meet on Friday at 4 P.M. in Seminar Room 114 of the Department of Physics.

Prospects for future meetings. According to present plans, the winter meeting on the Pacific Coast will be held on December 27 at the California Institute of Technology in Pasadena; and the 1943 Annual Meeting will take place on January 13–15, 1944, at Columbia University in New York City, in conjunction with a meeting of the American Association of Physics Teachers and with the first meeting of the newly-formed Electron Microscope Society of America.

New Home of the American Institute of Physics. The favorable notice of those who read this Bulletin is bespoken for the new home of the American Institute of Physics at 57 East 55th Street, New York City, the opening of which will occur (if the exceptional obstacles of wartime can be overcome) at the time of our January meeting. This stately and commodious building, formerly a private house of a magnificence now rare, will in the course of the years become the locale of the offices of the Institute and of some of its Founder Societies, the scene for conferences and committee meetings pertaining to our science, and generally the headquarters of American physics. The privilege of a local habitation, obtained by the four great engineering societies many years ago through Carnegie's munificence, has now become ours through the gifts of many members of the American Physical Society and of its four companion societies in the Institute. The purchase price of $70,000, itself a bargain due to the generosity of the former owner of the house, has already been met to the extent of $51,000 through such contributions. The Building Fund Committee hopes to receive soon the contributions of those who intend to contribute but have not yet done so. The Committee believes that it will be an enduring source of professional pride to be recorded among the donors of this new national home for physics. Contributions should be addressed to American Institute of Physics, 175 Fifth Avenue, New York 10, New York.

General Rules Relating to Papers

By vote of the Society on December 27, 1940, no paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for the meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of these abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review*.

Karl K. Darrow, *Secretary*,
American Physical Society,
Columbia University, New York 27, New York

PROGRAMME

Friday Morning at Ten O'Clock

(probably in Room 6)

Symposium on the Physics of Rubber and Other High Polymers (Beginning)

1. H. M. James, *Purdue University.*
Present Status of Theory of Elasticity of Rubber.

2. L. A. Wood and F. L. Roth, *National Bureau of Standards.*
Stress-Temperature Relations in Synthetic and Natural Rubbers.

3. W. B. Wiegand, *Columbian Carbon Company.*
Some Physical Properties of Natural and Synthetic Rubber.

4. J. H. Dillon, I. B. Prettyman and G. L. Hall, *Firestone Tire and Rubber Company.*
Hysteretic and Elastic Properties of Rubberlike Materials under Dynamic Shear Stresses.

5. M. Mooney, *United States Rubber Company.*
Drift and Relaxation of Rubber.

Friday Afternoon at 2.15 O'Clock

(probably in Room 6)

Symposium on the Physics of Rubber and Other High Polymers (Continued)

6. P. Debye, *Cornell University.*
Light Scattering in Solutions.

7. R. B. Barnes, *American Cyanamid Company.*
Physical Methods of Analysis of Synthetic and Natural Rubber.

8. H. A. Robinson, *Armstrong Cork Company.*
Some Physical Properties of Commercial Polymerized Methyl Methacrylate.

9. R. H. Kelsey and J. H. Dillon, *Firestone Tire and Rubber Company.*
Rheological Properties of Natural and Synthetic Rubber.

10. H. A. Schultz and R. C. Bryant, *B. F. Goodrich Company.*
A New Extrusion Plastometer.

Friday Afternoon at 2.15 O'Clock

(probably in Room 7)

Contributed Papers, Session A

A1. *K*-Electron Capture in Radioactive Silver. L. K. Hurst* and M. L. Pool, *Ohio State University.*—The failure to find x-rays[1] associated with the nuclear *K*-electron capture postulated[2] as characteristic of Ag^{106} led to a reinvestigation of the radioactivities induced in silver. Bombardments of Rh, Pd, and Ag with α, p, n, and d have given several long periods in the silver fraction. Of these the 8.2 day substance is best produced, free from the other periods, by the new reaction Rh^{103} α, n Ag^{106}. Results have thereby been obtained which gave definite evidence for *K*-electron capture. X-rays of 0.59 angstrom have been observed which are close to the $K\alpha$ x-rays of Pd. The excited Pd^{106} then emits a gamma-ray of 1.07 Mev. Electrons of 0.73 Mev of relatively low intensity have bee

observed and presumably are Compton recoils due to the gamma-ray. No beta-rays were observed. Electrons of very low energy associated with the fluorescence yield were present approximately in the amount expected. The ionization ratio of x-rays to gamma-rays indicates that for each K-electron captured a gamma-ray is emitted.

* Now in the U. S. Army.
[1] L. Alvarez, Phys. Rev. **54**, 495 (1938).
[2] M. L. Pool, Phys. Rev. **53**, 116 (1938).

A2. Artificial Radioactivity of Columbium and Zirconium. WILLIAM N. MOQUIN* AND M. L. POOL, *Ohio State University*.—Energy measurements have been made on the characteristic radiations emitted by radioactive columbium and zirconium. The assignments of the various periods already have been made through the use of neutron bombardments.[1] Deuteron and proton bombardments give very strong activities and lead to several new reactions. The isomer Cb^{93} emits a 0.94-Mev gamma-ray, 0.11-Mev electrons and 0.78-angstrom x-rays. The latter two observations indicate a very highly internally converted gamma-ray. The long period in zirconium emits gamma-rays of 0.94 Mev and beta-rays of 0.57 and 0.29 Mev. Proton bombardment of zirconium gave Cb^{92} with gamma-rays of 1.0 Mev, beta-rays of 0.59 Mev and x-rays characteristic of zirconium.

* Now in the U. S. Army.
[1] R. Sagane *et al.*, Phys. Rev. **57**, 1179 (1940).

A3. Beta-Ray Spectra of the Artificially Radioactive Isotopes, Pb^{205} and Bi^{207}. ARTHUR L. LUTZ,* M. L. POOL, AND J. D. KURBATOV, *Ohio State University*.—The beta-rays emitted by the artificially radioactive isotopes Pb^{205} (52 hours) and Bi^{207} (6.5 days) were studied by means of a newly built beta-ray spectrograph. Exposures of up to several half-life lengths were made on x-ray film. The beta-rays from the 52-hour (Pb^{205}) activity were found to form a line spectrum consisting of the energies, 185, 255, 267, and 308 kev. The first three were shown to be due to K, L, and M electrons, respectively, which were emitted by the internal conversion of a 270-kev gamma-ray. The last line is believed to be due to Compton recoil electrons expelled by a 470-kev gamma-ray. The presence of both gamma-rays is shown by lead absorption measurements. The 6.5 day (Bi^{207}) activity was found to have a more complicated line spectrum. Reproductions of the spectrograph films will be shown, and the energy values correlated with those obtained by absorption measurements of the beta- and gamma-rays. Evidence of decay by K-electron capture in both cases will also be presented.

* Now at Wittenberg College, Springfield, Ohio.

A4. Isolation of Pure Radioactive Cerium. J. D. KURBATOV AND M. L. POOL, *Ohio State University*.—The long life (140 days) radioactive isotope of cerium obtained by activation of lanthanum with deuterons has been isolated without addition of inactive cerium. The separation of cerium in minute concentrations from activated lanthanum consists of two processes of coagulation at different pH. The first is the coagulation of tetravalent cerium at pH 3.1–3.3 in the presence of MnO_4^-, NO_3^- and Na^+ while La remains in the solution.[1] The La contaminating the Ce portion after a single separation has been obtained as low as 0.005 percent La. It has been established that the separation of Ce in minute quantities is independent of its concentration, contrary to the concepts of conventional chemistry, but is affected by the ions in the solution. The Ce is freed from Mn by a second coagulation at a high pH after NO_3^- is replaced by Cl_2^- in solution. The isolation of radioactive titanium and ionium,[3] light and heavy tetravalent elements, has been reported previously. This bridges the gap between.

[1] L. L. Quill and H. L. Wilson, unpublished thesis, Ohio State University, 1937.
[2] Allen, Pool, Kurbatov, and Quill, Phys. Rev. **60**, 425 (1941).
[3] Kurbatov, Karjavina, and Samojlo, Comptes Rendus Acad. Sci. USSR **69** (1930).

A5. Investigation of High Energy Gamma-Ray of Na^{24} by the Photo-Neutron Method. M. GOLDHABER, G. S. KLAIBER, AND G. SCHARFF-GOLDHABER, *University of Illinois*.—For gamma-rays with an energy $h\nu$ above the threshold for photo-disintegration of Be^9 (1.62 Mev) or D^2 (2.18 Mev) $h\nu$ can be determined by the "photo-neutron method" previously described.[1,2] It consists in determining the energy of the photoneutrons from Be or D_2O irradiated by the gamma-rays under investigation, with a hydrogen-filled ionization chamber. Na^{24} has a gamma-ray of sufficient energy to disintegrate both Be and D. For several reasons it seemed of interest to apply the photo-neutron method for a redetermination of this gamma-ray energy. A source of Na^{24} of several hundred millicuries initial intensity, produced by bombarding sodium with 10.5-Mev deuterons from the University of Illinois cyclotron, was used in this investigation. The photo-neutron energies found were (0.34 ± 0.03) Mev for $Na^{24}+D$, and (1.13 ± 0.05) Mev for $Na^{24}+Be$. This leads to a mean value for the gamma-ray energy $h\nu=(2.87\pm0.05)$ Mev, in satisfactory agreement with two recent measurements, based on an analysis of the Compton electron spectrum produced by the gamma-rays of Na^{24}, which yielded values of (2.76 ± 0.6) Mev[3] and (2.94 ± 0.06) Mev[4].

[1] G. Scharff-Goldhaber, Phys. Rev. **59**, 937 (1941).
[2] G. S. Klaiber and G. Scharff-Goldhaber, Phys. Rev. **61**, 733 (1942).
[3] L. G. Elliott, M. Deutsch, and A. Roberts, Phys. Rev. **63**, 386 (1943).
[4] C. E. Mandeville, Phys. Rev. **63**, 387 (1943).

A6. Energy of Gamma-Rays from $Na^{24} \rightarrow Mg^{24}$. W. E. OGLE AND P. GERALD KRUGER, *University of Illinois*.—Gamma-rays from a source of 250 ± 200 mC of radiosodium were used to produce $\pm$electron pairs in the gas (air) of a cloud chamber. A lead collimator 40 inches long, $\frac{1}{2}$-inch high, and 1-inch wide provided adequate collimation so that it was easy to apply rigid rules to the selection of pairs. Only those showing no evidence of scattering and occurring within a 20° cone in the forward direction were accepted as good pairs. Six thousand pictures yielded 31 pairs, including two "triplets." Twenty-seven of these pairs occur between 2.41 and 2.89 Mev and give an average gamma-ray energy of 2.69 Mev. The other 4 pairs indicate two higher energy gamma-rays at 3.22 and 3.61 Mev.

There is some evidence that the 2.69 Mev group may be complex. This point is being investigated further. All of these energy values are subject to correction when the calibration of the mutual inductance used to measure the magnetic field is checked by the National Bureau of Standards. The gamma-ray energies calculated from the two "triplets" (pairs formed in the field of an electron) are 2.67 and 2.66 Mev. The accuracy and resolving power of this method of measuring gamma-ray energies will be discussed. The results of other investigations[1] indicate the existence of gamma-ray energies of $1.38\pm.03$ and $2.85\pm.09$ Mev. These values are compatible with the present results, since the pair production at 1.38 Mev is very small and the gamma-rays above 3 Mev are very weak.

[1] Elliott, Deutsch, and Roberts, Phys. Rev. **63**, 386 (1943); C. E. Mandeville, Phys. Rev. **63**, 387 (1943); M. Goldhaber, G. S. Klaiber, and G. Scharff-Goldhaber. Abstract No. A5, to be presented at this meeting.

A7. A Cyclotron Which Allows the Accelerated Particles to Emerge in a Direction Parallel to the Dee Interface. P. GERALD KRUGER, J. R. RICHARDSON, G. K. GROETZINGER, E. M. LYMAN, W. E. OGLE, M. E. NELSON, G. SCHWARZ, J. B. GREENE, R. T. ANDERSON, N. C. COLBEY, R. W. LEE, C. E. MCCLELLAN, D. SCAG, LLOYD SMITH, F. K. TALLMADGE, *University of Illinois.*—The construction of the dees, deflection channel and vacuum chamber of a cyclotron will be described. The design allows the accelerated ions to pass through an electrostatic deflecting field for one-quarter of a revolution and then to proceed through the magnetic fringing field for another quarter of a revolution before they leave the cyclotron vacuum chamber. This provides that the ions emerge in a direction which is parallel to the dee interface and perpendicular to the principal azimuthal plane through the long axis of the cyclotron magnet. There are several advantages to this arrangement: (1) Relatively low deflecting voltages are necessary. (2) The emerging ions at 10 Mev (100 μa or more) are satisfactorily mono-energetic. (3) Because of the favorable direction of emergence of the ions, it is easy to "pipe" the beam to a point many feet from the cyclotron. This allows adequate shielding to be placed between the cyclotron and other experimental apparatus, such as cloud chambers or counting apparatus. (4) It is convenient to place magnetic analyzing apparatus in the beam path near the cyclotron (but outside of the cyclotron magnetic field) and thus attain small currents of very monoenergetic ions for charged particle scattering and similar experiments.

A8. The Refractive Index in Electron Optics. I. OPATOWSKI, *Armour Research Foundation, Illinois Institute of Technology.*—The application of methods of geometrical optics for the investigation of electron trajectories requires the knowledge of the refractive index μ of the equivalent optical problem. A general formula for μ in terms of the electrostatic potential V and of the magnetic vector potential $\mathbf{A}$ is known. If $\mathbf{A}\neq 0$ this formula contains a unit vectos $\mathbf{s}$ parallel to the electron velocity, which is not known in general. It is, therefore, important that $\mathbf{s}$ be eliminated. This can be done only if a suitable integral of the equations of motion of the electron is known. If V and $\mathbf{A}$ are symmetric about an axis, $\mathbf{s}$ may be eliminated from μ by means of a momentum integral (Glaser). This elimination is generalized in the present paper to include cylindrical fields (not necessarily symmetrical) as well as some more general fields with a transversal field component. The result is reached by interpreting the magnetic scalar potential as a velocity potential of an ideal fluid and making use of the corresponding stream function to obtain an expression for μ. Both relativistic and constant mass are considered.

A9. Influence of Pressure on Intermetallic Diffusion. F. J. RADAVICH AND R. SMOLUCHOWSKI, *General Electric Company.*—The influence of elastic deformation of crystal lattice on diffusion is of considerable theoretical interest because it might help to estimate the various factors involved in the mechanism of intermetallic diffusion. On the other hand, it has also a bearing upon many technical problems in which diffusion occurs in strained material. The experimental difficulty lies in obtaining high pressures at temperatures which are high enough to produce well-measurable concentration gradients. The experiments were performed on the Al–Cu system. Two bars, one of pure aluminum and the other of a 9 atomic percent (4 weight percent) Al–Cu alloy were welded together in vacuum. The welded sample was placed in a mold and subjected to high pressures at 500°C for a week. The analysis was made spectrochemically and the diffusion coefficients calculated from the concentration vs. distance plots. There was no measurable change of the diffusion rate observed at the pressure of 1500 kg/cm². However, at 7000 kg/cm², a decrease of the rate of diffusion was found corresponding to a decrease of the diffusion coefficient by about 30 percent at a copper concentration of 2 atomic percent.

A10. A Series Generator as a Negative Resistance. G. H. FETT, *University of Illinois.*—A series generator in the operating range below maximum voltage possesses both d.c. negative resistance ($-V/I$), and incremental negative resistance ($-dV/dI$). It is shown that the incremental negative resistance is equal to $Kn-R$, where n is the speed, K the induction factor per unit of field current, and R is the armature circuit resistance. Since the series generator has the incremental resistance property, it will support oscillations if the tuned circuit has the proper constants. It is shown that a generator load consisting of a separately excited motor can be represented by a condenser of sufficient size (in the order of farads) that oscillations at mechanically feasible frequencies of 0.2 to 1.5 cycles per second can be obtained. It is shown analytically that the magnitude of the capacitance varies directly with the moment of inertia of the motor armature and inversely with the square root of the induction factor. It is shown experimentally that the frequency of oscillation of the circuit depends upon the motor induction factor and moment of inertia, and slightly upon the circuit resistance. The amplitude of oscillation is controlled by the circuit resistance.

A11. New Experiments About the Magnetic Current. FELIX EHRENHAFT, *New York City.*—Experimentally we have established the existence of magnetic currents in our discovery of magnetic ions, magnetolysis of water and the electric field around magnetic currents.[1] The following is a continuation of these experiments. In the darkfield we observe that microscopic testbodies (e.g. chromium, manganese, nickel) move in spiral paths or parts of spirals around a completely constant vertical homogeneous magnetic field in air of atmospheric pressure, created in a magnetic condenser (magnet poles of soft Swedish iron apart 0.5–1.5 mm, diameter 6–12 mm). In dilute copper sulfate solution blue light scattering particles of colloidal size become visible in the darkfield between the aforesaid magnetodes. Each single colloid particle spirals up or down around the constant homogeneous vertical magnetic field ending its movement on the upper or lower magnetode. These are the well known copper-particles that precipitate on iron.[2] The described experiments in gases and liquids prove clearly the existence of bodies charged simultaneously electrically and magnetically. Because of their electric charges they move around the magnetic field along the electric force lines closed in circles. Because of their magnetic charges, north or south, they move up or downwards. The helix is the resultant path.[3]

[1] Felix Ehrenhaft, Phys. Rev. **60**, 169 (1941); **61**, 733 (1942); **63**, 216, 461 (1943); **64**, 43 (1943).
[2] Remsen, see H. V. Juepter, La lumiere electrique **10**, 468 (1883).
[3] The experiments can be seen at C. Zeiss, Inc., New York City.

SATURDAY MORNING AT 9.45 O'CLOCK

(probably in Room 6)

Symposium on the Physics of Rubber and Other High Polymers (Concluded)

11. I. FANKUCHEN AND H. MARK, *Brooklyn Polytechnic Institute.*
Crystallization of Long-Chain Compounds.

12. S. D. GEHMAN AND J. E. FIELD, *Goodyear Tire and Rubber Company.*
X-Ray Observations on the Structure of Rubber and the Size and Shape of Rubber Crystallites.

13. A. V. TOBOLSKY, I. B. PRETTYMAN AND J. H. DILLON, *Firestone Tire and Rubber Company.*
Stress Relaxation of Natural and Synthetic Rubber Stocks.

14. H. S. SACK, *Cornell University.*
Hysteresis Losses in High Polymers.

15. P. H. EMMETT, *Johns Hopkins University.*
Measurement of the Surface Area of Carbon Black by Low Temperature Absorption.

16. R. S. SPENCER AND R. F. BOYER, *Dow Chemical Company.*
Second-Order Transition in High Polymers.

SATURDAY MORNING AT 10.15 O'CLOCK

(probably in Room 7)

Contributed Papers, Session B

B2. Recording Negative Ions and Electrons in a Gas with a Geiger-Müller Counter. R. T. K. MURRAY, *Polytechnic Institute of Brooklyn.*—Free electrons and negative ions present in a gas have been recorded by allowing them to enter a counter through a window consisting of a small open aperture. The pressure outside the counter could be adjusted above or below the optimum counter pressure by suitable pumping. Negative ions once in the counter suffer electron detachment at the high values of X/p and are therefore recorded. Electrons and negative ions can be introduced into the counter by diffusion, by convection in the gas flow and by electrical convection under an applied electric filed. For free electrons the electric drift velocity for weak fields is still large compared to the jet velocity which has an upper limit slightly greater than the velocity of sound thereby making it possible to convect free electrons into the counter against an outwardly directed gas jet at the aperture. Electrons from a thermionic source in electronegative oxygen at 4-mm pressure have been recorded. This is possible since the average distance for electron attachment is large compared to the distance between the source and the aperture. It is planned to develop the apparatus further for the efficient detection of space-localized low energy ionizing particles.

B3. Study of Cosmic-Ray Air Showers Using the Method of Coincident Bursts in Two Unshielded Ionization Chambers. L. G. LEWIS AND E. W. LEWIS, *University of Chicago.*

—Simultaneous bursts of ionization were observed in two unshielded thin walled ionization chambers. These chambers, which were 35 cm in diameter, were filled with argon to a pressure of 100 cm Hg. The signals, which the bursts produced on the grids of two FP-54 tubes, were amplified by d.c. amplifiers employing inverse feedback. The output of each amplifier was connected to a sensitive string galvanometer. Both galvanometer deflections were recorded simultaneously and continuously on the same photographic film. This method of observation makes it possible to plot size-frequency distribution curves for single bursts in each chamber, as well as a family of curves giving the rate of burst coincidences as a function of separation of the chambers. This last family of curves, with size of burst as a parameter, yields information concerning the lateral density distribution of extensive cosmic ray showers. Measurements have been made near Echo Lake, Colorado (elevation 10,650 ft.) and further investigations are contemplated at Idaho Springs, Colorado (elevation 7556 ft.), and at Chicago. Analysis of these coincidence curves for different altitudes should yield the energy spectrum for the shower producing radiation.

B4. The Origin of Large Cosmic-Ray Bursts. R. E. LAPP, *University of Chicago.*—Large cosmic-ray bursts under different thicknesses of iron have been investigated with the simultaneous use of an ionization chamber and Geiger-Mueller counters. From an analysis of the transition curve obtained for iron, three types of bursts are distinguished: (1) t_0-bursts observed in an unshielded chamber; (2) t_m-bursts produced in a 12-cm iron shield; (3) t_μ-bursts originating under a shield equivalent to at least 20 radiation units. The t_0 bursts were found to be coincident with the simultaneous triggering of the G-M counter arrangements which were designed to detect extensive atmospheric showers (A showers). Thus a t_0 burst represents a high density of particles in an A shower (the so-called core). On the other hand, only about 5 percent of the t bursts were found to be coincident with A showers; this is regarded as further evidence that the great majority of t_μ bursts at sea level are produced by mesotrons. Analysis of the burst data obtained with a 12-cm iron shield shows that the t_m bursts are a complex of t_0 and t_μ bursts and in addition it seems that some of the t_m bursts originate neither from the cores of A showers nor from mesotrons. Experiments are in progress to determine the origin of this fraction of the t_m bursts.

B5. An Analysis of Large Cosmic-Ray Bursts. MARCEL SCHEIN AND R. E. LAPP, *University of Chicago.*—Through the cooperation of the Carnegie Institution over five years of burst data obtained at Cheltenham, Teoloyucan, and Huancayo were made available to us. These data have been analyzed and size-frequency burst distribution curves were obtained for 72, 2285, and 3350 meters elevation. Because of the great amount of data available these curves are more accurate than those[1] published earlier; this is especially true for the largest size bursts. The sea-level data are discussed with reference to the theoretical calculations of Christy and Kusaka,[2] and a discussion is given of the possibility of determining the spin of the mesotron from the sea-level size-frequency distribution which is presented. The origin of bursts under thick shields at high altitude is also considered.

[1] M. Schein and P. S. Gill, Rev. Mod. Phys. 11, 267 (1939).
[2] R. F. Christy and S. Kusaka, Phys. Rev. 59, 414 (1941).

B6. Production of Mesotrons by Non-Ionizing Radiation at Altitudes of 10,618 ft. and 14,230 ft. JULIUS TABIN, *University of Chicago.*—The production of mesotrons in various materials was studied by means of an apparatus consisting of 46 Geiger-Mueller counters arranged in 12 three-, four- and fivefold coincidence sets. Each individual pulse actuated a neon light which was recorded photographically. The producing layers consisted of different thicknesses of paraffin, aluminum, iron, and lead. Special care was taken to eliminate the influence of air showers. It was found that at the above-given altitudes the rate of production of both single and multiple mesotrons by non-ionizing rays is a very small effect and did not exceed under optimum conditions more than 2.5 percent of the intensity of the penetrating component. The maximum production of single mesotrons was found to exist in paraffin. The penetrating power of the produced mesotrons was determined in lead and it was found that a large fraction of these mesotrons was stepped by a thickness of 11 cm. Experiments are in progress to investigate the nature of the mesotron producing radiation.

B7. Secondary Radiation Produced by Cosmic-Ray Primaries in Paraffin. MARIO IONA JR., MARCEL SCHEIN, AND JULIUS TABIN, *University of Chicago.*—In recent stratosphere balloon experiments counter coincidences have been observed between the passage of vertical penetrating particles and multiple secondaries emerging below layers of paraffin. From electromagnetic theory no appreciable shower production is to be expected in the thicknesses of paraffin used. However, the experiments show that a large proportion of the single penetrating rays passing through 5 or 10 cm of paraffin in the stratosphere emerge as several particles. The relative number of these secondaries increases rapidly with altitude in the upper atmosphere. This strongly indicates that this effect is caused by a direct interaction of the primary cosmic radiation with the nuclei of paraffin. The majority of the multiple secondaries are ejected under a very small angle below the paraffin.

B8. Electrons in Equilibrium with Mesotrons. H. E. STANTON, *University of Chicago* (*Introduced by Marcel Schein*).—The problem of the origin of the soft component of cosmic rays in the atmosphere which arises from the mesotron component is considered in such a way as to enable a calculation of the energy spectrum of the electrons. The theory is based on the cross sections derived by Bethe and Heitler and the simple theory of mesotron decay. It is assumed that the mesotron has spin zero and decays into a single neutrino and electron with emission equally probable in all directions in the reference frame of the mesotron. A modified set of diffusion equations is set up and formal solutions found with the boundary conditions for no in-

coming electrons or photons. By the use of approximate methods, it is possible to calculate the spectrum of the electron component once the mesotron spectrum is known, and these results can be compared with experimental values obtained at the lower altitudes.

B9. Non-Shower Producing Particles in *A* Showers. P. AUGER AND AN. ROGOZINSKI, *University of Chicago.*—Penetrating particles in extensive atmospheric showers (*A* showers) were investigated by means of Geiger-Mueller counters. It was found that *single* particles emerging below lead screens up to 12.5 cm thicknesses, were associated with particles which traversed counters placed in horizontal distances up to 15 meters from those counters which were located below the lead screen. A careful study of the observed phenomena shows that part of these events could be attributed to knock-on processes arising from collisions between single mesotrons and electrons.

SATURDAY AFTERNOON AT TWO O'CLOCK

(probably in Room 6)

Contributed Papers, Session C

C1. On Some Physical Properties in the Problem of Rubber. GEORGE ANTONOFF, *Fordham University.*—In the course of his work on surface tension, the author evolved some methods which can be applied to the study of the problem of rubber. Two will be mentioned here. There exists parallelism between rubber mixed with pigments and paints which are a mixture of oil and pigments. Pigments which increase the breaking stress of films of oil will also reinforce the rubber and vice versa. In pastes, as a function of concentration, a brusque change in properties is observed when fluid paste becomes plastic. Similarly, in rubber, there is an abnormal zone where the properties change as soon as a certain concentration of pigment is attained. Properties of solutions of rubber vary with time. Similar changes can be observed in liquids leading to formation of rubber. Some fraction from turpentine has been heated. Its properties changed with time. Suddenly the transparent liquid changed into a brown rubber-like mass. Analogous but small changes can be observed in ordinary liquids. They can be made apparent by surface tension method described by the author.[1]

[1] G. Antonoff, J. Phys. Chem. **46**, 492 (1942).

C2. A Proposed Substitute for Instrument Oil. S. BLOOMENTHAL, *Automatic Electric Laboratories, Chicago, Illinois.*—Porpoise jaw oil is superior to any known petroleum derivative for lubrication of mechanical instruments that must operate for long periods of time without attention. Because of the present scarcity of the first mentioned oil, a substitute lubricant was looked for among certain esters and oils that are fluid at −30°F. Help in this search was obtained from the Laboratory of the Distillation Products Company, Rochester, New York. Tenacious low vapor pressure films on metal may explain the exceptional lasting qualities of porpoise jaw oil. $C_6H_4(COOC_4H_9)_2$, $C_8H_{16}(COOC_8H_{17})_2$ and Distillation Products Company Synthetic Lubricating Oil have low vapor pressures and are fluid at −30°F. Far better results were obtained with these substances in the lubrication of automatic telephone dials than with light petroleum or fish liver oils, and it is believed that a satisfactory substitute for porpoise jaw oil has been found.

C3. The Energy of Dissociation of Hg_2. J. G. WINANS AND M. P. HEITZ, *University of Wisconsin.*—*D* for Hg_2 has been determined by a modification of the method used by Koernicke.[1] The absorption intensity of the 2540 Hg band was measured photographically at two different temperatures with constant density. With the equation of Gibson and Heitler, *D* was calculated from measurements of two temperatures and the ratio of absorption intensities at these temperatures. Constant vapor density was obtained by using an absorption cell containing a drop of mercury small enough to be completely evaporated at the lowest temperature measured. The final value of *D* was 0.060 ± 0.003 volt. This agrees within experimental error with the value obtained by Koernicke.

[1] E. Koernicke, Zeits. f. Physik **33**, 219 (1925).

C4. Raman Spectra of 2,5-Dimethyl-1,5-hexadiene and 2,5-Dimethyl-2,4-hexadiene. FORREST F. CLEVELAND, *Illinois Institute of Technology.*—Continuing work on olefinic hydrocarbons, Raman frequencies, relative intensities, and depolarization factors have been obtained for (**A**) 2,5-dimethyl-1,5-hexadiene and (**B**) 2,5-dimethyl-2,4-hexadiene. The relative intensities and depolarization factors were obtained by use of a Gaertner microdensitometer. The two molecules are isomers differing only in the location of the two double bonds contained in each molecule. In **A** the double bonds are at the ends of the chain and the molecule thus contains two $XYC=CH_2$ groups. Mean values observed in the previous work on non-cyclic mono-olefins for the five frequencies characteristic of this group are 1299, 1412, 1649, 2977, and 3075 cm^{-1}. Corresponding frequencies for **A** are 1303, 1414, 1651, 2977, and 3075 cm^{-1}; the diolefin **A** thus has the same frequencies as the mono-olefins. In **B** the double bonds are symmetrically located in the middle of the molecule; the molecule thus contains the group XYC–CHZ. Dipentene, the only olefin investigated previously in this laboratory that contained this group, had the

characteristic frequencies 1246, 1682, 3012, and 3050 cm^{-1}. Corresponding frequencies for **B** are 1227, 1663, 3012, and 3040 cm^{-1}. The lowering of the 1682 dipentene frequency to 1663 in **B** is due to the conjugation of the double bonds.

C5. Polymer Spectra of a Cyanine Dye. RICHARD W. MATTOON, *University of Chicago* (*Introduced by J. Franck*).—In dilute aqueous solutions 1,1′-diethyl-2,2′-cyanine chloride has two broad absorption bands with maxima at 4900 and 5230A, while at concentrations $\geqq 10^{-3}$ molar a new, intense, and exceedingly narrow absorption band appears at 5730A (G. Scheibe, E. Jelley, and others). According to Scheibe this new band belongs to a system of long chains of molecules formed by polymerization. In the present investigation the occurrence and behavior of this "*P* band" were studied for thin dye films deposited on glass from solutions containing water. The *P* band shifts about 50A to $>\lambda$, becomes broader and weaker, and finally disappears as the water is removed by pumping and/or by increasing the temperature. This behavior is reversible if water vapor is readmitted. The position of the *P* band enables a measurement of the humidity of the atmosphere surrounding the film. A second, weaker absorption band at 5430A behaves in a manner similar to that of the *P* band in its dependence upon water vapor pressure and temperature. Measurements of fluorescence polarization, etc., taken from the literature and the present results are used for an interpretation of these bands.

C6. Isotope Shift in Magnesium. L. G. MUNDIE AND K. W. MEISSNER, *Purdue University*.—The previous investigations concerning the isotope shift of magnesium have been repeated and extended by means of an improved atomic beam source and a Perot-Fabry interferometer. The values of Meissner have been checked to within experimental error in most cases. In addition, several new lines have been resolved and their isotope shift determined. The $3\,^1P-m\,^1D$ series has been resolved from $m=3$ out as far as the member $m=11$. In this series the values of $\Delta\nu(=\nu_{26}-\nu_{24})$ seem to converge to a value of about 0.068 cm^{-1} rather than the value 0.056 cm^{-1} obtained by Meissner. The isotopic shifts of the members $m=5$ and $m=6$ of of the series $3\,^1P-m\,^1S$ have been measured. The results obtained are discussed in connection with the theoretical work of Vinti, who assumed the splitting to be solely a mass effect. The experimental and theoretical values of $\Delta\nu$ agree in sign, but the former are usually larger by a factor of about two.

C7. Forbidden Lines of Bismuth Bi I. S. MROZOWSKI, *University of Chicago*.—A group of forbidden lines corresponding to transitions between energy levels belonging to the electronic configuration $6p^3$ was observed in the spectrum of neutral bismuth. The experimental arrangement for excitation of the spectrum was similar to the one used by the author in a work on forbidden lines of lead (configuration $6p^2$) and also in a recent work on the line spectrum of bismuth.[1] The photographs of 6 lines and their hyperfine structures were obtained with the 30-foot grating spectrograph. The lines observed are: λ3014, λ4597, λ4615, λ5640, λ6476, and λ8755. The two last ones are especially interesting, since the structure of the first one gives a confirmation of the value of the hyperfine structure separation reported by the author[1] for the ground level $^4S^0_{3/2}$ (a value almost 3 times as large as the one accepted in the past). The last line is situated quite far in the infra-red and its photograph can be obtained only with considerable difficulty. The hyperfine structure of all the lines is showing the predominantly magnetic dipole character of the forbidden radiation with a possible only slight admixture of electric quadrupole radiation, since no components corresponding to a change $\Delta F=\pm 2$ were observed.

[1] S. Mrozowski, Phys. Rev. **62**, 526 (1942).

C8. A New Adsorption Isotherm and Polymolecular Films on Solids. WILLIAM D. HARKINS AND GEORGE JURA, *University of Chicago and the Universal Oil Products Company*.—Films adsorbed from vapors on the surfaces of solids exhibit phases of different types, among which gaseous and condensed phases are particularly important. The equation for a condensed monolayer, either liquid or solid, on an aqueous subphases may be written

$$\pi = b - a\sigma \qquad (1)$$

in which π is the film pressure, and σ the molecular area. By a method devised by Bangham it is possible to calculate the film pressure (π) for a film on a solid, and it is found that at the lower film pressures at which Eq. (1) is valid, the film is monomolecular, but that, as the film pressure increases the film becomes polymolecular without any change in the value of the slope (a). By the use of the Gibbs adsorption Eq. (1) was changed into

$$\log (p/p_0) = B - (A/V^2) \qquad (2)$$

in which p_0 is the gas pressure at saturation, A and B are constants for the condensed film, V is the volume of gas adsorbed (STP) when the pressure is p. Equation (2) is found to give a linear relation over a very much greater range of pressure than any earlier adsorption isotherm. The area of a very finely divided crystalline solid may be determined by an absolute method described earlier.

C9. An Adsorption Method for the Determination of the Area of a Solid. GEORGE JURA AND WILLIAM D. HARKINS, *University of Chicago and the Universal Oil Products Company*.—An adsorption isotherm developed by the writers has the form

$$\log (p/p_0) = B - (A/V^2)$$

in which B and A are constants and V is the volume (STP) of gas adsorbed at the pressure p, and p_0 is the saturation pressure. It is found that the areas of the surfaces of the solids (per gram) are proportional to the square roots of the slopes A, or

$$\Sigma = kA^{\frac{1}{2}}$$

where Σ is the area per gram. An absolute method for the determination of the area of a finely divided crystalline solid consists in dividing the heat of immersion of the solid, covered by a duplex film of the liquid, in the liquid itself.

The amount of heat divided by the surface energy of the liquid gives the area of the solid, and thus the value of the constant k is obtained. Thus (1) becomes

$$\Sigma = 4.06\, A^{\frac{1}{2}}$$

The equation of Brunauer, Emmett, and Teller gives the number of molecules in the first monolayer. If the area of the nitrogen molecule is assumed to be $14.8A^2$, the areas obtained by our method agree with theirs within plus or minus 9 percent.

C10. The Stability of a Mercury Arc as a Function of Cathode Pool Area. PAUL L. COPELAND AND CARROLL LUFCY, *Illinois Institute of Technology.*—The work of Copeland and Sparing[1] on the increase in the stability of a mercury arc with the cathode spot anchored suggested a systematic statistical study of arc life as a function of the size of the cathode pool. An experimental low pressure mercury arc was started repeatedly and the measured times of extinction were recorded. The results established a correlation between the surface area of the cathode pool and the average life of the arc. When the cathode pool was large the life was relatively short, and the average life increased rapidly as the area of the cathode pool was decreased.

[1] Copeland and Sparing, Phys. Rev. 59, 115 (1941).

Additional Contributed Paper

SATURDAY MORNING AT 10.15 O'CLOCK

B1. Counter Corrections at High Counting Rates. TRUMAN P. KOHMAN, *University of Wisconsin.*—A method has been developed for determining counter losses at high rates which does not involve assumptions regarding counter mechanism. Several pairs of sources are used, the members of each pair being approximately equal. For each pair the sources are counted separately and together, and a first approximation to the fractional correction for the combined source count is calculated on the assumption of no losses in the separate source counts. The corrections are plotted against recorded rates and the best smooth curve drawn. Second approximations to the combined source corrections are made by using this curve to correct the separate source counts, and a better curve obtained. The process of successive approximations is repeated until the curve converges to a stationary position. With a Geiger-Müller counter and Neher-Harper circuit, the apparent resolving time decreased markedly with increasing rate, as expected from theory. Simplified assumptions about the mechanism yielded a theoretical expression for the average deadtime τ_N as a function of true rate N: $\tau_N = \tau_{\min} + (\tau_{\max} - \tau_{\min})\rho/(\rho + N)$. $\tau_{\max}$ is the deadtime following an isolated pulse, $\tau_{\min}$ is the deadtime of the smallest recordable pulse, and ρ characterizes the rate of recovery of the field strength around the counter wire. This equation fits the observations satisfactorily.

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(To be sent to Professor B. J. Spence, Northwestern University, Evanston, Illinois)

I EXPECT to attend the dinner of the American Physical Society at the Georgian Hotel, Evanston, at seven o'clock on Friday evening, November 12, 1943. My party will consist of ____ persons.